Alaska Park Science

National Park Service
Alaska Support Office
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Photograph courtesy of U.S. Geological Survey

National Park Service photograph

Kristy Balluta and Janell Kukaruk, USGS Fisheries Interns, select a sockeye salmon to radiotag.

Top-Right: Dan Young, a biologist with the National Park Service, holds up a beach spawning fish from Kijik Lake in the Lake Clark watershed. Beach spawning fish tend to be older, longer, and deeper bodied compared to fish spawning in nearby shallow streams.

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National Park Service
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Connections to Natural and Cultural Resource Studies in Alaska's National Parks

Summer 2003

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Alaska Park Science

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Sharing Alaska's Natural and Cultural Heritage

Parks Featured in this Issue

Cover photograph © Randall Davis

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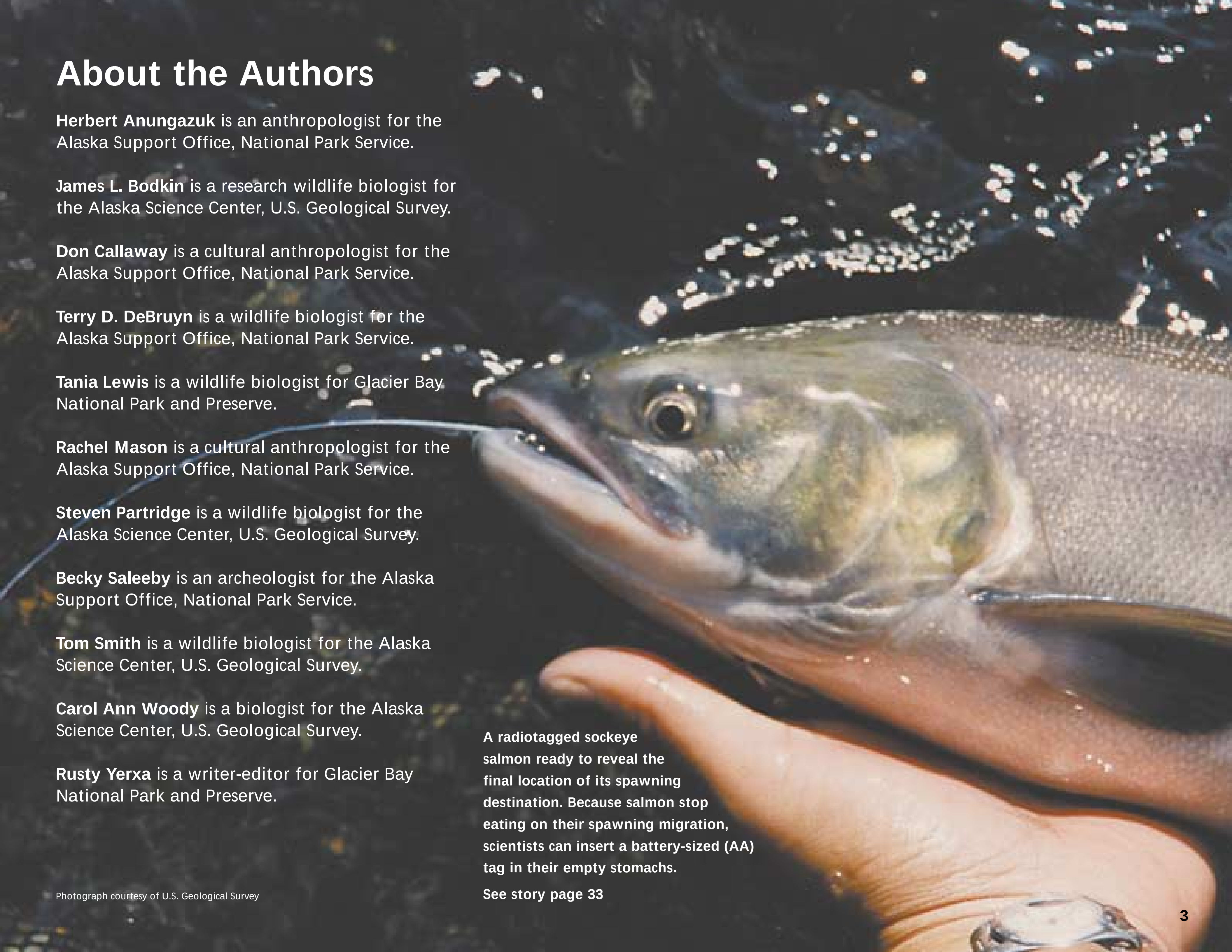

Photograph courtesy of U.S. Geological Survey

A radiotagged sockeye salmon ready to reveal the final location of its spawning destination. Because salmon stop eating on their spawning migration, scientists can insert a battery-sized (AA) tag in their empty stomachs.

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Figure 1: Sea otters are in the first stages of recolonizing Glacier Bay. The red circles represent subtidal clam sites.

Return to Glacier Bay

By James L. Bodkin

Introduction

A sound unheard for centuries is once again resonating above the turbid waters of Glacier Bay. The sound is one of rock hammering against clam in rapid-fire succession and it signals the return of the sea otter *(Enhydra lutris)* to its former habitats in Southeast Alaska. The sound also signals the beginning of a process that will, with little doubt, result in profound and persistent changes in the marine communities of Glacier Bay. Some of these changes are predictable, while others will be unanticipated. Without understanding the range of effects of sea otters, management of many marine resources may be severely impaired for decades to come. Fortunately, because sea otters are easily observed and their prey easily studied, methods and approaches to studying sea otters and their ecology are perhaps better developed than for any other marine mammal *(Riedman and Estes 1990)*.

For several reasons Glacier Bay National Park and Preserve provides an excellent laboratory for studying the effects of sea otters on marine communities. First and foremost, sea otters are in the early stages of recolonizing Glacier Bay. This provides the opportunity to describe the marine community, as it exists before sea otters exert their influence, and to document how the community changes as sea otters become established. Because Glacier Bay is large, it will take many years for sea otters to reoccupy all habitats in the bay. The opportunity to compare similar habitats in Glacier Bay, both with and without sea otters, and before and after sea otter colonization, provides an experimentally powerful design. This can then allow researchers to assign cause based on observed change *(Figure 1)*. In addition, the protected waters of Glacier Bay provide a laboratory that is, and will likely remain, relatively unaffected by human activities such as contamination, fishing, logging, and mining, which could potentially confound the interpretation of ecological study. It was under consideration of these attributes that we began our work nearly ten years ago to understand the effects of sea otters on the structure and function of near-shore marine communities in Glacier Bay.

The Decline and Recovery

At the end of the nineteenth century along nearly the entire shore of the North Pacific Ocean, the sound of sea otters foraging could no longer be heard. This was the result of a commercial fur harvest that began about 1750 and ended in 1900 with the near extinction of the species *(Kenyon 1969)*. The first efforts to conserve sea otters occurred in 1911. At that time sea otters received their first protection under the International Fur Treaty, and likely numbered just several hundred animals scattered in 11 populations between central California and Russia, with most individuals occurring in the Aleutian Islands. No sea otter populations persisted between Prince William Sound in Alaska and the Big Sur coast of California. During the twentieth century, extant sea otter populations exhibited a general pattern of recovery, with growth rates from about 5% to 13% per year and displaying concurrent patterns of range expansion *(Bodkin et al. 1999)*.

The next efforts to conserve and aid in the recovery of sea otter populations began in 1965 and consisted of translocations from Amchitka Island and Prince William Sound in Alaska to Oregon, Washington, British Columbia, and Southeast Alaska *(Jameson et al 1982)*. Between 1965 and 1969, 412 sea otters arrived at several loca-

Sea Otter photos courtesy of Randall Davis © 2003

Kelp Forest photo courtesy of U.S. Geological Survey

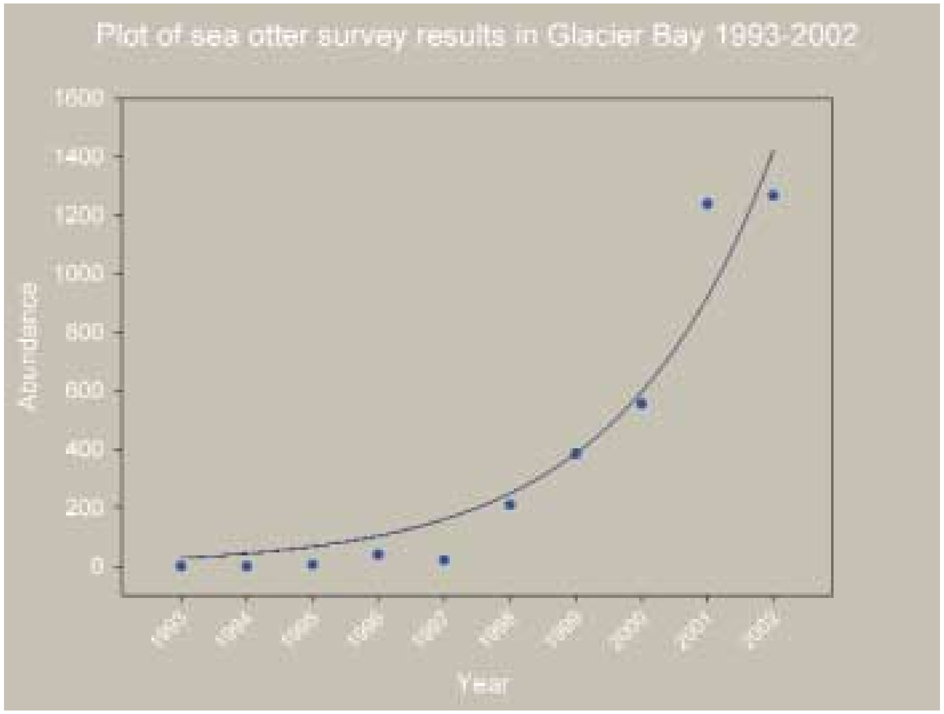

Figure 2: Since 1993, sea otter populations have increased dramatically.

Photo courtesy of U.S. Geological Survey

Figure 3: A diverse assemblage of animals reliant on the kelp forest characterize the kelp forest community.

Where sea otters are present, they effectively limit the abundance of sea urchins by actively consuming individuals larger than about one inch in diameter. As a result of this predation on urchins, which limits urchin size, abundance, and mobility, urchins do not have a large grazing effect and consequently kelp forests flourish.

tions in Southeast Alaska, including areas adjacent to Glacier Bay National Park and Preserve in Cross Sound. Although surveys of sea otter populations in Southeast Alaska were infrequent, results through at least 1988 indicated that the population was increasing about 20% annually with simultaneous expansion of range *(Pitcher 1989)*. By 1988 sea otters were common in Cross Sound and immigration into Icy Straits was evident. In 1993 the first sea otters were observed in Glacier Bay, although annual surveys indicate permanent residence was not established until 1998. Since that time, population growth in Glacier Bay has been phenomenal. It is almost certainly exceeding the reproductive potential of the species, and thus likely representing contributions from both births and immigration from outside the bay. *(Figure 2)*.

A "Keystone" Species

Our understanding of the role sea otters will play in modifying the Glacier Bay marine ecosystem will benefit from previous studies of the effects of sea otter foraging in other locales *(Estes and Palmisano*

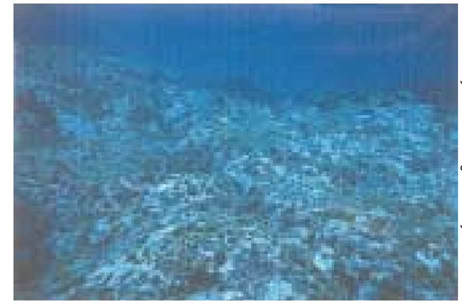

Photo courtesy of U.S. Geological Survey

Figure 4: Urchin barren.

1974, Simenstad et al. 1978, Kvitek and Oliver 1988, Kvitek et al. 1992). Probably the best example of sea otter effects comes from the description of sea otters as ecological "keystone" species in kelp forest communities of the coastal North Pacific Ocean *(Estes and Duggins 1995)*. Within these shallow rocky habitats occur several species of sea urchin *(Stronglycentrotus sp.)*, marine herbivores that actively graze on algae. This includes the brown algae that often forms the conspicuous and productive kelp-forests that exist along many coastlines. Where sea otters are present, they effectively limit the abundance of sea urchins by actively consuming individuals larger than about one inch in diameter. As a result of this predation on urchins, which limits urchin size, abundance, and mobility, urchins do not have a large grazing effect and consequently kelp forests flourish. In turn, kelp forests provide habitat, refuge, and forage for a complex community of invertebrates, fishes, birds, and mammals. A high biomass of kelps and a diverse assemblage of animals reliant on the kelp forest characterize the kelp forest community. *(Figure 3)*.

Alternatively, when sea otters are

absent, urchin populations respond to reduced predation by increased abundance and average size. As this happens, the level of grazing by urchins increases, which can eventually eliminate the forest and much of the associated animal community that is supported by the kelp forest. This urchin-dominated community is commonly referred to as an "urchin barren." It is characterized by large and numerous sea urchins, little algae or canopy-forming kelp forests, and the reduction or absence of kelp-associated fauna. *(Figure 4)*. Additionally, in the absence of sea otter predation, some of the other preferred prey species, such as abalone *(Haliotis sp.)*, crab *(e.g., Cancer sp.)*, and mussels *(Mytilus sp.)*, can also increase in abundance and average size *(Lowry and Pearse 1973, Garshelis et al. 1986, VanBlaricom 1988)*.

Although habitats suitable for supporting kelp forests exist in Glacier Bay, much of the shallow water habitats in Glacier Bay are soft-sediment, such as mud, sand, gravel and cobble that will not provide optimum substrate for kelp forests. We can expect the transformation of some urchin barrens into kelp forests. In order to determine what kinds of direct and indirect effects can be anticipated as sea otters occupy and forage in these soft-sediment marine communities, the U.S. Geological Survey's Alaska Science Center, in cooperation with Glacier Bay National Park and Preserve, initiated a program consisting of three integrated avenues of research. The first consists of documenting the distribution and abundance of sea otters in and around Glacier Bay and how that changes over time (see above). The second consists of describing the diet of recolonizing sea otters; identifying species, number and size of prey; and describing the diet as it changes. The third component of our program consists of estimating the density, sizes, and composition of species occurring in intertidal and subtidal habitats, before and after sea otter recolonization. The third part focuses initially on those species that sea otters consume directly.

The Diet of Glacier Bay Sea Otters

To date we have observed the results of more than 3,000 sea otter foraging dives in Glacier Bay *(Bodkin et al. 2001, 2003)*. The primary data that we collect while observing feeding sea otters includes: success or failure, and species, number and sizes of prey consumed. *(Figure 5)*. Sea otters successfully recover one or more prey on about 85% of their foraging dives in Glacier Bay. Although the number of prey types consumed by sea otters exceeds 150 species *(Estes and Bodkin 2001)*, the bulk of their diet can be classified into the general taxonomic groups of bivalve mollusks (clams and mussels), echinoderms (sea urchins

Photograph courtesy of U.S. Geological Survey

Figure 5: Researcher observing sea otter foraging dives.

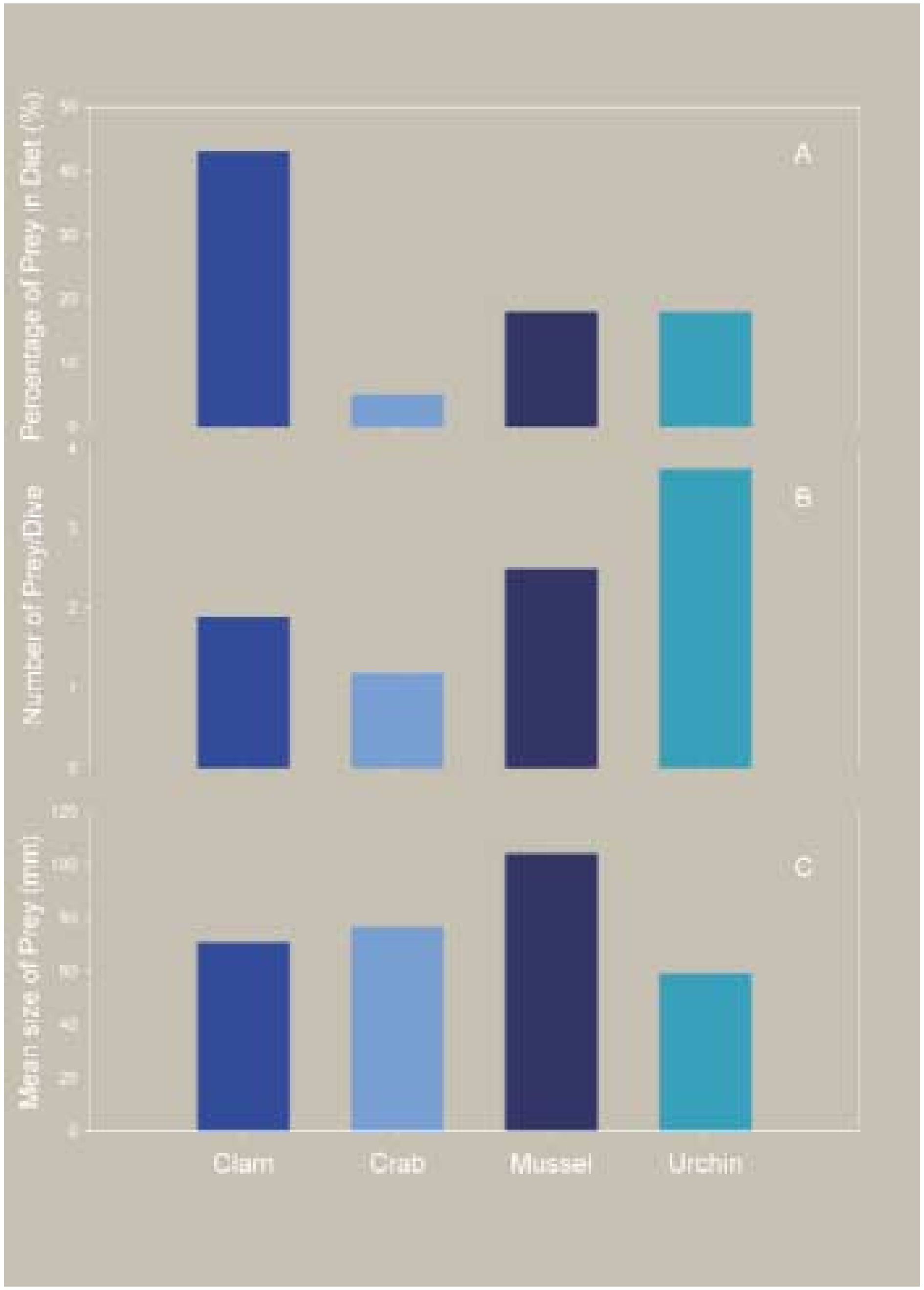

Figure 6: Sea otter diet composition (A), number of prey (B) and mean size of prey in mm (C) in Glacier Bay, Alaska, 1993-2002

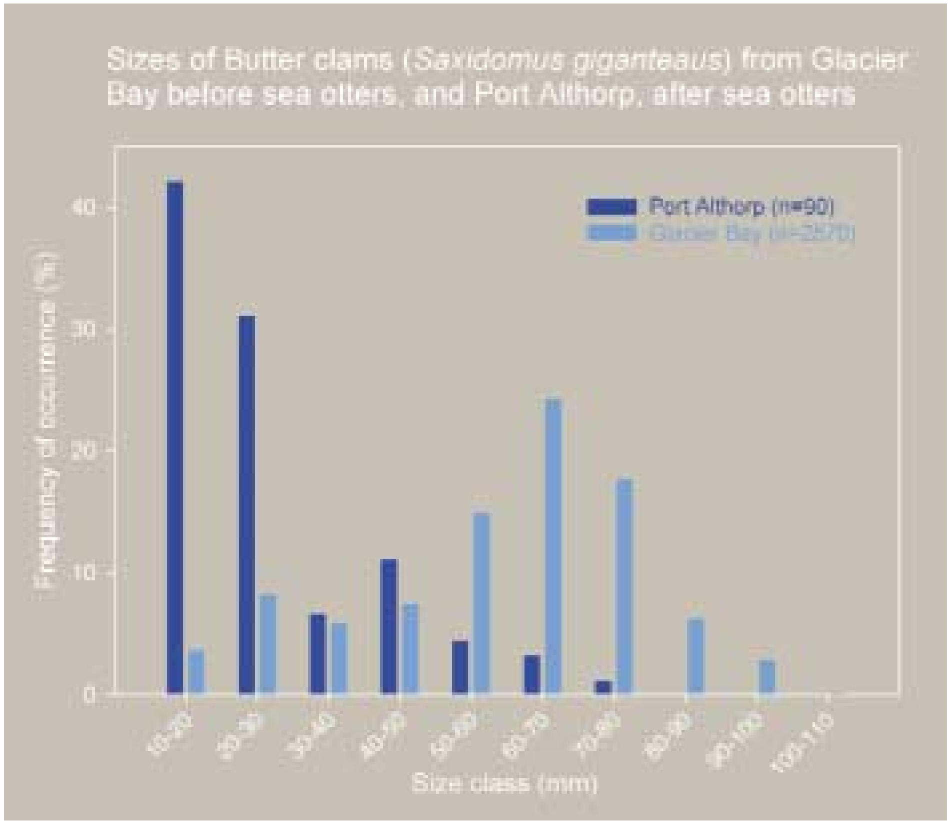

Figure 7: Dramatic declines in the size of butter clams have been observed.

Photograph courtesy of Randall Davis © 2003

and stars), and crustaceans (crabs). Although the diet we observed in Glacier Bay varies within the area occupied by sea otters, it consists largely of invertebrates that reside in, or on, unconsolidated substrates such as mud, sand, gravel and cobble. Over all areas, bivalve clams (species of *Mya*, *Saxidomus*, *Protothaca* and *Serripes*) constitute 43% of the observed diet, urchins (*S. droebachiensis*) 18%, horse mussels (*Modiolus modiolus*) 18%, and crabs (species of *Cancer*, *Telmessus*, *Chionoecetes* and *Paralithoides*) 5%. *(Figure 6)*. Relatively rare species include octopus *(Octopus dofleini)*, snails *(Fusitriton oregonensis and Neptunea sp.)*, the fat innkeeper worm *(Echiurus sp.)*, the basket star *(Gorgonocephalus caryi)*, and the sea cucumber *(Cucumaria fallax)*.

Effects of Sea Otters on Clam Populations

Because sea otters have not resided in large numbers for a long period at our study sites in Glacier Bay, we were unable to compare our measures of prey populations before and after sea otter recolonization. As an approximation of changes we might expect in Glacier Bay, we have compared clam populations before sea otters arrived in Glacier Bay to a nearby and similar area in Port Althorp, where sea otters have been present for about 20 years. *(Figure 7)*. Although we have sampled crabs, mussels, urchins and other otter prey in Glacier Bay, the following example from our subtidal clam data serves as an example of the types of data obtained. In addition, through comparison with nearby Port Althorp, we can approximate what we might expect in Glacier Bay as a direct result of sea otter foraging.

Between 1998 and 2002 we sampled 13 subtidal clam beds in Glacier Bay before sea otters occupied those sites. For comparison, in nearby Port Althorp where sea otters have been foraging for more than 20 years, we sampled an additional 5 sites. We selected the sites based on the presence and high abundance of clam siphons in Glacier Bay and based on sea otter foraging and fresh clam shell fragments in Port Althorp. We used a diver-operated suction dredge to excavate 50 cm by 50 cm quadrats to depths of about 25 cm at each site to determine species composition and sizes of subtidal clams. *(Figure 8)*.

Average densities of all clams were about six times greater in our Glacier Bay sites (59 per quadrat) than at our Port Althorp sites (10 per quadrat). Densities of the butter clam *(Saxidomus gigantea)*, a large and preferred sea otter prey, were more than 10 times higher in Glacier Bay than at Port Althorp. Probably of equal or greater importance is that the average clam was much larger in Glacier Bay than in Port

… long-time residents of the community of Elfin Cove in Port Althorp observed dramatic declines in the abundance and sizes of clams concurrent with the arrival of sea otters about 20 years ago.

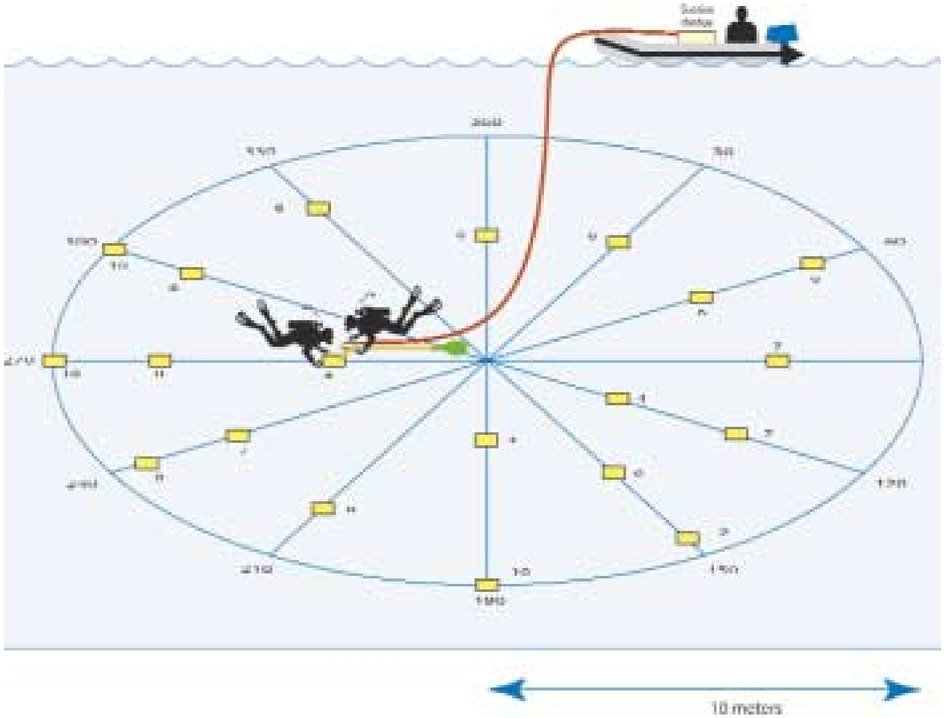

Figure 8: Schematic drawing showing excavation of quadrats utilizing the suction dredge.

Althorp: butter clams between 70 mm and 90 mm long (~3 in) were most common in Glacier Bay, compared to Port Althorp, where the majority of clams were 10 mm to 30 mm (~1 in). These differences in density and sizes resulted in estimates that placed the total butter clam biomass of the Glacier Bay sites about 75 times that of Port Althorp. Additionally, long-time residents of the community of Elfin Cove in Port Althorp observed dramatic declines in the abundance and sizes of clams concurrent with the arrival of sea otters about 20 years ago.

The pattern of higher densities and larger average sizes, of subtidal clams in Glacier Bay compared to Port Althorp, was consistent for intertidal clams, urchins, crabs, and mussels as well. These preliminary contrasts, while not unequivocal, suggest that the sea otter effect of reducing densities and sizes of preferred prey will likely also occur in Glacier Bay. Our ability to anticipate and understand both the direct and cascading effects of this predation will improve management decisions regarding marine resources in Glacier Bay. While predicting ecosystem level responses to a disturbance such as that imposed by recolonizing sea otters affords a broad suite of challenges, it also offers opportunities to advance our understanding of how these complex systems function.

Cascading Effects of Recolonization

The experimental and logistic situation offered in Glacier Bay has provided the opportunity to pursue and acquire many of the numerous data sets that will be required to document and understand the direct effects of sea otter foraging. In some cases, particularly relative to the effects of urchin removal, we will likely capture both the direct effect of reduced urchin densities and sizes, plus the cascading effect of increased algal production. However, it is also likely that other effects will be more difficult to understand, if at all. Two examples may serve to illustrate the potential breadth of effects induced by sea otter foraging.

One regards a species that is both competitor and prey for the sea otter, the octopus. Octopuses are likely near the top of the food web in Glacier Bay. We have observed "gardens" of emptied clams and other mollusks numbering into the hundreds that evidence the residence of one or more large octopuses. What will be the indirect effect on resident octopus populations of sea otters removing most of the clam biomass? What will the direct effects of otter predation on octopuses be? Reduced octopus densities may be a result. What might be the effect of reduced octopus densities on the marine communities in general?

Another example concerns several species of sea ducks that spend the winter in Glacier Bay in large numbers and who compete for many of the same prey. Sea ducks, including goldeneye *(Bucephala sp.)*, harlequins *(Histrionicus histrionicus)*, scoters *(Melanitta sp.)* and the long-tail duck *(Clangula hyemalis)*, are among the most abundant species of bird during the winter in Glacier Bay, numbering into the tens of thousands. Much of what these sea ducks forage for are bivalve mollusks, including many of those that sea otters will consume and eventually reduce in densities and average size. It is difficult to predict what the cumulative effects of reduced prey densities and sizes will be on sea ducks. On one hand, fewer clams and mussels would likely support fewer sea ducks. On the other hand, it is possible that sea otter predation will result in an increase in the abundance of smaller clams that could benefit sea ducks. Part of our challenge in preparing for the recovery of sea otter populations is

What will be the indirect effect of sea otters removing most of the clam biomass on resident octopus populations? What will the direct effects of otter predation on octopus be? Reduced octopus densities may be a result, and what might be the effect of reduced octopus densities on the marine communities in general?

Photograph courtesy of U.S. Geological Survey

Commercial, recreational, and subsistence harvest of species in Glacier Bay such as crab, urchin, and clams compete directly with sea otters, resulting in less of those prey species.

anticipating the types of direct and indirect effects that sea otters will induce.

Implications to Humans

Economically, ecologically, and culturally important marine resources will unquestionably be altered in terms of abundance and size over the coming years in Glacier Bay, as sea otters continue to recolonize former habitat. Commercial, recreational, and subsistence harvest of species such as crab, urchin, and clams clams compete directly with sea otters, resulting in less of those prey species that sea otters and humans both seek. In this context, the return of sea otters may be regarded as undesirable. Alternatively, the marine ecosystems of Glacier Bay will once again contain a top-level carnivore that was part of the evolutionary history of this marine ecosystem. As a result, the sound of the hammering rock against clam, can signify a step toward, rather than away from, an ecosystem that contains more of the components and functions of a complete ecosystem. And in this context, perhaps there is a trace of pride that we can collectively take from the return of the sea otter, that will help us strive toward the restoration, rather than continued degradation, of all ecosystems.

Acknowledgments

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The Wales/Deering Subsistence Producer Analysis Project

By Don Callaway

In 1994 the National Park Service entered into a cooperative agreement with the Alaska Department of Fish and Game (ADF&G) subsistence division to conduct social and cultural research in the communities of Wales and Deering. This article draws extensively from the original text found in the report *The Production and Distribution of Wild Food in Wales and Deering, Alaska, (Technical Paper #259)* authored by James S. Magdanz, Charles J. Utermohle and Robert J. Wolfe. The full text of the final report can be found on the ADF&G website—http://www.state.ak.us/adfg/subsist/download/TP259.pdf .

Regulatory Context and the Intent of this Research Project

The establishment of new national parks and preserves in Alaska under the Alaska National Interest Lands Conserva-tion Act (ANILCA) nearly doubled the park acreage in the United States. For those parks established or enlarged by ANILCA, subsistence uses by local residents are permitted in accordance with the provisions of Title VIII.

Paraphrasing Section 803 of Title VIII, we can define subsistence use as the customary and traditional use in Alaska of fish, wildlife, and other renewable resources for direct personal or family consumption, for the making and selling of handicraft articles from the non-edible by-products of fish and wildlife taken for direct personal or family consumption, and for customary trade, barter, or sharing for personal or family consumption.

The communities of Wales and Deering, the subject of this research, are affiliated with the Bering Land Bridge National Preserve (BELA). The establishment of the preserve includes protecting the viability

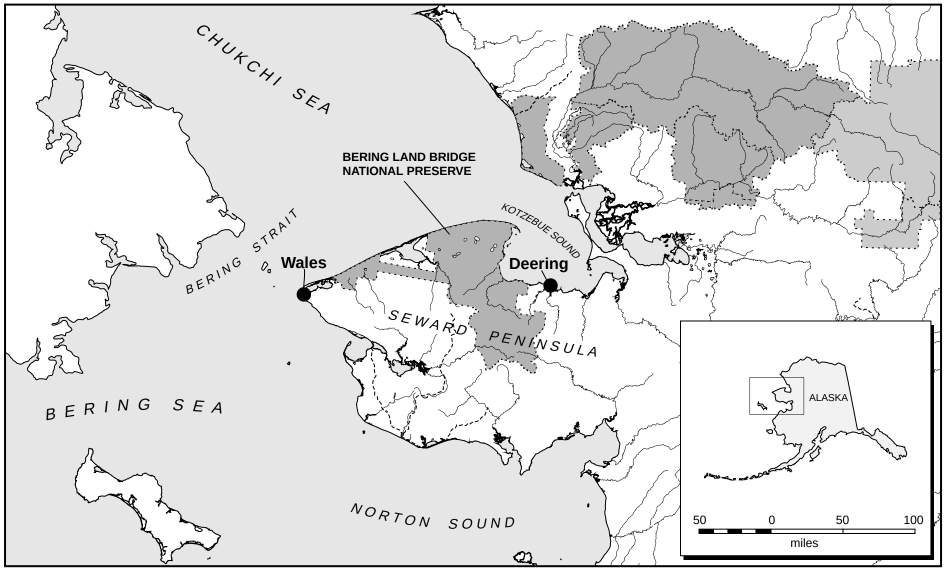


Figure 1. Northwest Alaska, including the study communities of Wales and Deering.

Left: Residents of Wales, in 1916, stand in front of a meat cache at Cape Prince of Wales. Numerous other caches in the background attest to Wales' population before the 1918 influenza epidemic.

Photograph from the Robert Steiner Collection, 91-164-64, Archives and Manuscripts, Alaska and Polar Regions Department, University of Alaska Fairbanks

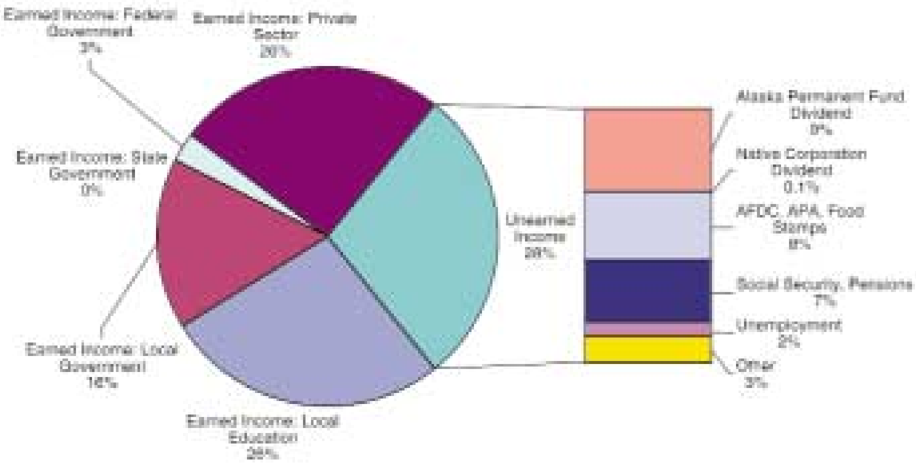


Figure 2. Sources of personal income, 1994.

of subsistence resources in addition to protecting habitat for fish and wildlife.

Two clear purposes of the park were involved in the development of the Wales/Deering analysis. First, information from each household in both communities details the amount of harvest for every species of natural resources used by that household. This information details the community's dependence on wildlife resources and in addition helps park managers gauge the impact of human harvest on resource populations. Critical to managing any natural resource is biological data on the size of a wildlife population and cultural information on the amount of human harvest.

Second, while the nutrition and economic aspects of wildlife harvests seem the critical issue, in fact, it is the social relations in the harvest, processing, and sharing of those resources that are of paramount concern to the rural Native Alaskans of the region. Subsistence resources, and the activities associated with their harvest provide more than food. Participation in family and community subsistence activities, whether it be clamming, processing fish at a fish camp, or seal hunting with a father or brother, provide the most basic memories and values in an individual's life. These activities define and establish a sense of family and community. They teach how a resource can be identified, methods of harvest, efficient and non-wasteful processing of the resource, and preparation of the resource into a variety of food items.

The sharing and distribution of resources establishes and promotes the most basic ethical values in Native and rural culture — generosity, respect for the knowledge and guidance of elders, self-esteem for the successful harvest of a resource, and family and public appreciation in the distribution of the harvest. No other set of activities provides a similar moral foundation for continuity between generations. The single most respected and reinforced role for young men in the community is to be a successful hunter who distributes the fruits of that success widely within the community. The documentation of these social relationships, a major intent of the research design, has several useful outcomes. Information gained from the project is used in the regulatory process. Positive regulatory findings ensure continued access to these wildlife resources for the communities in question. In addition, the findings of this project have substantial importance in answering a number of significant questions in the scientific literature and in interpreting the cultural values, ideals and behaviors of these Iñupiaq communities.

The Setting: Participating Communities

The communities of Wales and Deering are located in Northwest Alaska— a sparsely populated area bisected by the Arctic Circle *(Figure 1)*. Temperatures range from the minus 50s °F [-50°C] in winter with nearly no sunlight, to the high 70s °F [25°C] in summers that are characterized by little darkness. Permanent year-round settlement in one location is a relatively recent phenomenon in the region. The current locality of Wales *(Figure 3)*, though, has a long history of occupation due to its exceptional access to marine mammals and its strategic location for trade with Siberia. Wales, with 500 inhabitants at its peak, was one of the largest traditional settlements in northwest Alaska before the 1918 influenza epidemic. In contrast, Deering *(Figure 4)* was not occupied continuously during the nineteenth century. As many as 400 people may have been living in the Deering area prior to 1850, but this population lived in over a dozen small seasonal settlements. Currently each community has about 150 people, more than 90

Figure 3. Wales, 1998

percent of Iñupiaq descent.

Both communities have low per capita income. In 1994 both communities had a per capita income (from all sources) of about $7,000 which was about a third of the per capita income ($23,417) for the state during that year *(Figure 2)*. Both communities are heavily dependent on the harvest of wildlife resources with per capita harvests of about 700 pounds. By comparison the average U.S. per capita consumption of meat, fish and poultry is about 220 pounds. Although the per capita harvest for both communities is about the same, the composition of those harvests varies substantially due to differences in ecological setting. Wales is much more dependent on marine mammals, especially walrus, while Deering, located in a sheltered bay inside Kotzebue Sound, harvests about equal amounts of seal, fish and caribou *(Figure 5)*. In summary, we find two indigenous communities with very low incomes that are heavily dependent on traditional resources.

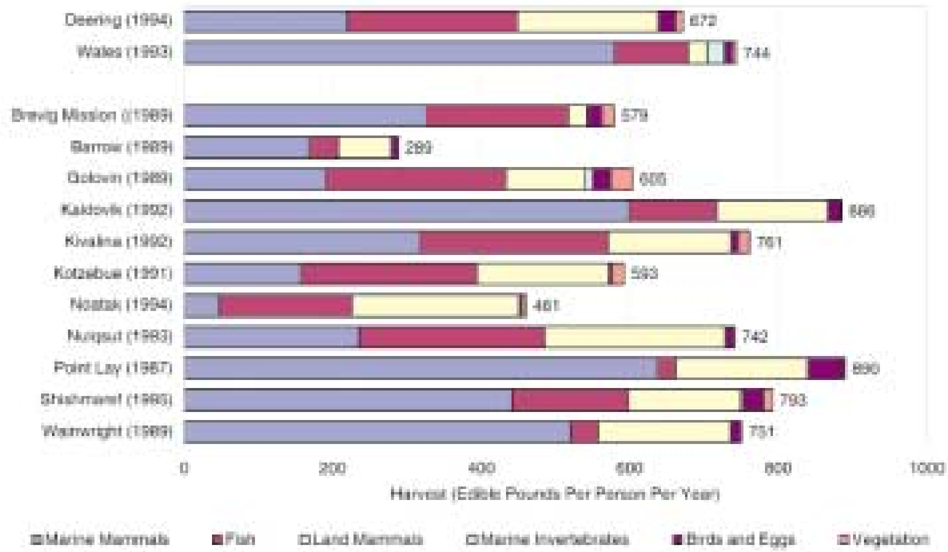


Figure 5. Estimated harvest in 14 northwest Alaska communities. Deering's and Wales' harvest of pounds per person per year were similar to other northwest communities.

Research Design

In both communities about 84% of available households were interviewed (42 in Wales, 37 in Deering). Before the research began, approval for the research was obtained from the respective local governments. The household survey form asked questions about the harvests of wild foods (by species) by the respondent's household during the previous year. The survey also obtained information on the age, sex, employment and income of each permanent resident of the respondent's household. In addition to the standard harvest inquiries, interviewers asked each household to identify the people who harvested, processed or distributed 12 categories of subsistence resources for the respondent's household, and whether or not these individuals lived in his or her household. Detailed genealogical data was also obtained from participating households and entered into "Legacy" software. Surveys required 15 minutes to two hours to complete. The data was analyzed using the Statistical Package for the Social Sciences (SPSS) and Excel programs. The analysis employed a variety of statistical techniques, including hierarchical clustering.

Figure 4. Deering, 1998

Significant Findings:

The Long Term Continuity of Kin-based Production Groups

Since the nineteenth century indigenous groups in northwest Alaska have experienced tremendous dislocations—the advent of commercial whaling, which introduced diseases and social restructuring of traditional relationships; starvation due to the crash of the caribou herds in the late nineteenth century; and missionary impacts on indigenous beliefs especially after the terrible epidemics of the early twentieth century, which brought a devastating mortality to nearly a third of the population. However, many of the underlying beliefs, values and practices that are linked to subsistence activities have persisted.

The surveys demonstrated continuity between the organization of contemporary households and those documented by ethnohistorians during the mid-nineteenth century. Although contemporary households in 1994 were somewhat smaller and less complex, they essentially mirrored the subsistence networks described for "local families" in the 1850s. In essence the key elements of sharing, respect for elders, ethical treatment of "animals" and support for those in need have been sustained for at least 150 years.

In the larger American culture, families support themselves predominantly on the wages produced by the parents of small nuclear families. This research demonstrates that households in northwest Alaska rarely function as independent entities. The organization of the harvest, processing and distribution of wildlife resources on which these communities base their survival rely

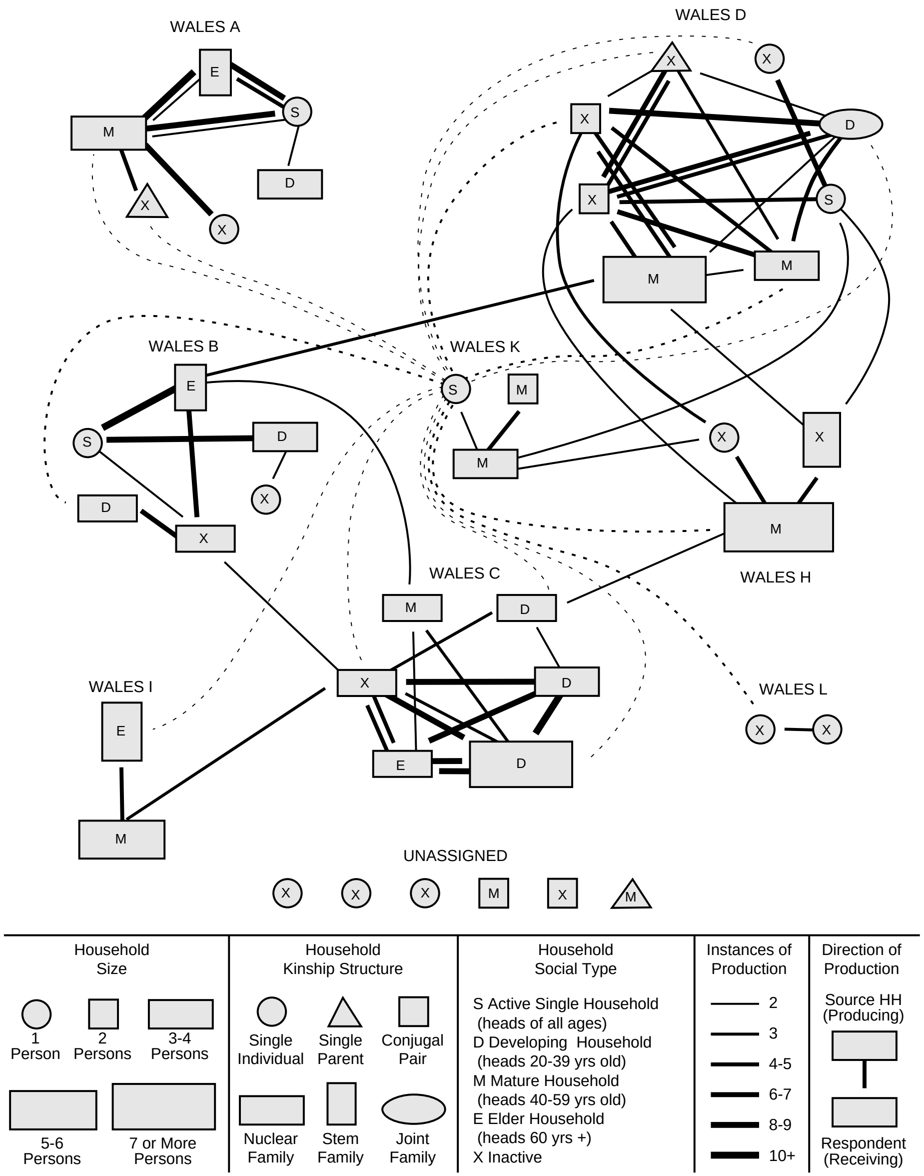


Figure 6. Wild food production and distribution networks in Wales, 1994. Each grouping (Wales A, B, etc.) represents a kinship network. Each polygon (rectangle, triangle, etc.) represents a household. The solid lines represent instances of harvesting, processing, and distribution of wild foods between households. The thicker the line, the more instances of production. The dotted lines link one man, who each summer harvests a considerable amount of salmon and distributes most of these fish throughout the entire community.

on extensive sharing between households in the community. In almost all cases, these households that share wildlife resources are linked through kinship. Most often these kinship linkages are between parents and children, grandparents and grandchildren, siblings (of either sex) or between aunts/uncles and nephews/nieces. Thus an elderly parent may have his/her wildlife nutritional needs met by children living in other households. These reciprocating households linked by kinship are called kinship networks.

Eight production and distribution networks were identified in Wales and six in Deering *(Figure 6)*. Networks ranged in size from 2 to 41 people, occupying 2 to 11 households. On average, networks harvested 12,723 pounds of wild foods (735 pounds per person). About 90% of inter-household sharing in Wales occurred within networks and about 75% of the inter-household sharing in Deering occurred within networks. Of the six different types of kin relationships, household heads related by parent-child relationships were most likely to be found in the same network. Networks organized around one elder parent household were more productive than networks organized around two elder sibling households.

It is noteworthy that in Wales, 79% of wildlife harvests came from marine mammals, principally walrus. Walrus are hunted by crews of men in locally made skin boats or with commercially manufactured boats. Perhaps because of this crew structure, relationships within networks were stronger and boundaries between networks more distinct in Wales than in Deering. In addition, the relatively high cost of maintaining the equipment and supplying the crew for marine mammal hunting meant that crews were more likely to be organized around higher income households in Wales.

By contrast, in Deering, the majority of the harvest (62%) came from land mammals and fish. Subsistence activities in Deering were less costly because land mammals could be pursued by a single man with a snowmachine and sled; an entire crew was not needed.

Generally and consonant with indigenous value systems, the flow of wild foods within the networks tended to be from the active single and active elder households to the inactive and developing households. While highly productive single-person households were important to network harvests, active elder households were more likely to make contributions in every economic sector: wild food harvest, earned income, and unearned income.

Six households in Wales and three households in Deering, either did not cooperate with any other households or did not harvest any wild foods, and thus were not included in any networks. All of these were short-term households occupied by teachers or other non-local government employees.

Resource Management Conflicts Resulting from Kin-based Production Groups

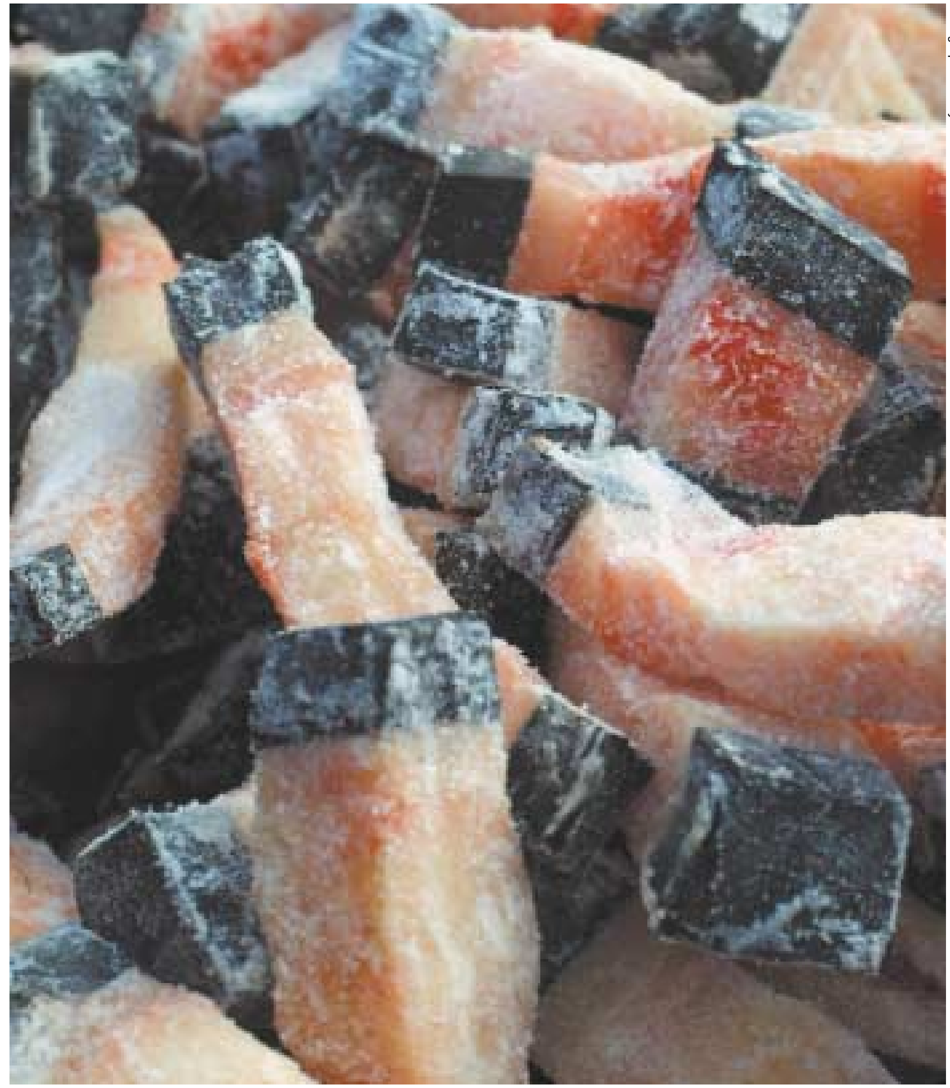
One key feature of these results with respect to National Park Service management of natural resources is the cultural conflict in expectations as to who provides for a family and what should be the entity

Photograph courtesy of James Magdanz © 2003

Rita Olanna, her son Percy, and her sister Pauline, skin a bearded seal at their extended family hunting camp near Brevig Mission. They live in three different households, but cooperate extensively in the production of wild food. All but one of the food productions networks in nearby Wales and Deering were based on extended family relationships.

connected with management regulations. Western game management practices come out of a tradition of managing the impacts of sport hunting. Buttressed by the cultural expectation that individuals provide for their nuclear families, most game management in Alaska focuses on limiting the amount of a resource (e.g., caribou) that one hunter can take in a day (or a given time period). This is called the individual bag limit. In contrast, a single male Iñupiaq hunter may harvest a number of caribou and distribute them to multiple households, related to him by kinship, within the community. Thus traditional practice, where a single hunter receives status and community approval for harvesting many animals and distributing them widely, comes into direct conflict with western game management practice.

The NPS and other agencies, in some instances related to decreasing animal populations, have modified some of their regulatory practices to allow for community bag limits or designated hunters. Community bag limits set a ceiling on the total community harvest of a resource (e.g., caribou), but limit no particular hunter within that community. "Designated" hunters are individuals selected by non-active or elderly households to harvest animals for their use. Thus the active hunter uses the designating household's bag limit and may harvest animals for a variety of households without exceeding his own individual limit. Without these provisions, the specialization



Photograph courtesy of John Robson © 2003

Sharing of food is integral to Native and rural Alaskan communities. Here, whale blubber has been processed and prepared.

in caribou harvesting observed in Deering families in 1994 (when the caribou bag limit was 15 per day) would have been illegal in 1977 (when the caribou bag limit was one per year). In times of resource shortages, the use of individual bag limits hobbles the most productive hunters. *(Figure 7)*.

On occasion the NPS, the Federal

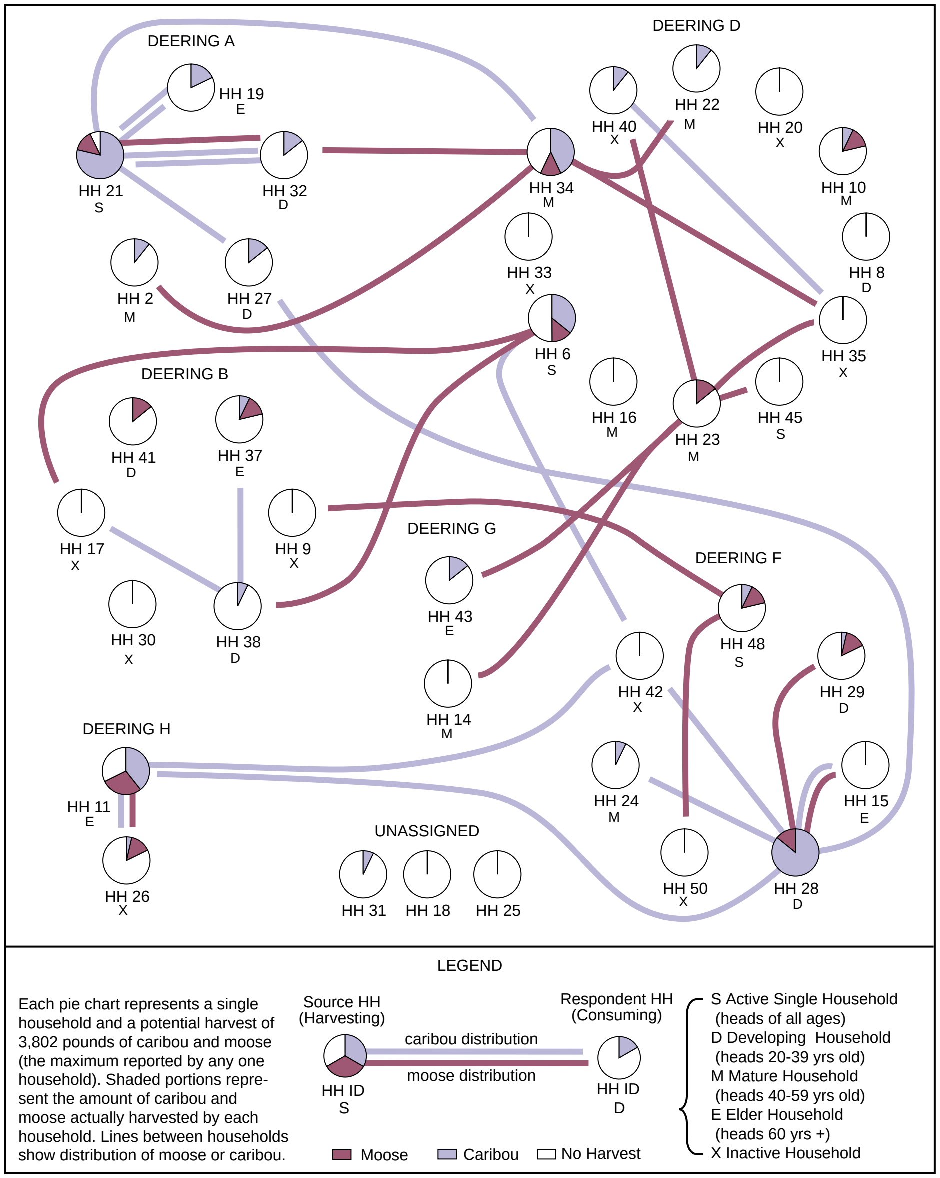


Figure 7. Harvest and distribution of large terrestrial mammals, Deering 1994. Two households were particularly important in the distribution of meat to other households. Household 21 and 28 reported harvesting one-third of Deering's total caribou harvest and distributed that harvest to eight other households in four networks.

Subsistence Board and the Alaska Board of Game have attempted, through the use of community bag limits and designated hunters, to preserve the traditional organization of the hunt in Iñupiaq communities. However, recently on state lands, urban hunters have used the courts to force the Alaska Board of Game to reorganize the hunt to favor individual rights on a statewide basis, instead of extended families and communities on a local basis.

Realistic game management requires local compliance. The results of this research clearly indicate the dynamics of contemporary subsistence practices for indigenous communities in the area and underscore the necessity of flexibility in western game management practices. Extended-family networks were not simply accommodated by indigenous management; they were part of indigenous management. These networks facilitate communication among members, encourage responsible harvests and use of fish and wildlife, and discipline members who fail to comply with group norms.

In essence much of western game management in Alaska highlights an equity issue. Euro-American regulations regarding individual bag limits reflect who has political and legislative power within the state. Non-indigenous Alaskans hold different beliefs about whether individuals or families and communities should be the basis for allocation.

Factors That Sustain Local Family Networks

In these Iñupiaq communities, local family networks have survived when so much else has changed. A strong local family network provides its adult members with a high degree of individual freedom: to work or not work, to hunt or to fish, to raise children or grandchildren — such freedom is all but impossible for adults in an economically independent nuclear family. In most areas of rural Alaska, dependence on a cash economy is risky, especially for men who work in construction, for jobs tend to be temporary. Jobs in the schools and health clinics are more permanent, but even those jobs are subject to changes in public funding priorities that are out of local control. Given distance from markets, limited skills in a small labor pool and a variety of other factors, it is extremely difficult to operate a private business.

There is no guarantee that current levels of public spending — upon which most jobs depend — will continue. In the daily business of subsistence living, people who are part of a local family network seem better prepared to survive the uncertainties of life in Alaska. A household without employment can depend on other households for food, equipment, and supplies. When hunting is poor, every household in a network benefits from the success of even a single hunter in the network. Wild foods play an essential role in maintaining the physical and emotional health of thousands of Alaskans. This is a tremendous responsibility for the agencies that participate in the management of those resources.

Regulatory Conflicts Associated with the Use of Modern Technology in Subsistence Activities

In 1850, the six to eight local families in the study communities probably would have spent much of the year living in separate, small, local family-based settlements spread across each "society's" territories. In

Photograph courtesy of John Robson © 2003

Participation in family and community subsistence activities provide the most basic memories and values in an individual's life.

1994 Wales and Deering represented permanent, localized-year-around settlements. The permanent settlements are a product of a number of social, economic and historical factors. Permanent settlements were often localized around stores that provided western technology and a stable source of foodstuffs. Fragile elders and the infirm, who formerly may have faced considerable difficulty keeping up (especially during periods of scarce resources), found increased security in permanent settlements. Thus the advent of commercial whaling and "trading posts" provided considerable incentive for some form of permanent settlement.

The numerous epidemics which caused precipitous declines in human populations accompanied by the crash of the caribou herd were also localizing forces. The most important contemporary reason for the creation of permanent settlements, however, is the demand of outside institutions that require children attend school on a nine month basis. Parents were faced with the choice between occupying traditional seasonal camps and losing their children or living with their children in permanent settlements established by the government and/or religious institutions. The factor that made this latter choice more palatable was the use of increasingly efficient western technology in their subsistence pursuits.

In 1994 there was less need to disperse. With modern transportation, families could fish, hunt, and gather throughout their traditional territories, yet return to their permanent homes in a matter of hours. Children could attend school and every family member could appreciate the benefits of local services, such as electricity and running water, which were not available in seasonal camps. Despite this, the nineteenth century settlement pattern was still in evidence seasonally, when some family members moved to temporary hunting and fishing camps. This contemporary settlement pattern presents some difficulty and requires sensitivity on the part of western land managers, particularly the NPS. The use of snowmachines during the winter months presents little impact to the environment; however, spring and summer use of all terrain vehicles may impact park aesthetic and resource values. The key to mitigating these potential conflicts is sustained dialogue between both parties with a foundation of empirical evidence, as represented by this study, to facilitate the discussion.

The Long Term Impact of Subsistence Activities on Wildlife Populations

In some quarters there is the perception that growth in Alaska Native populations threaten to outstrip Alaska's fish and wildlife. The data from this project do not support this conjecture, neither from a harvesting or a population growth perspective. For example, analysis from this project when coupled with time series data from Kivalina, a nearby community, suggests that total subsistence harvests have not increased in recent decades. While the population of Kivalina has doubled during the latter half of the twentieth century, per capita harvest of wild foods have declined by half, resulting in a stable level of subsistence demand. The factors in Kivalina's declining per capita harvests — the replacement of hungry dog teams by mechanical transportation, increased availability of imported foods and a variety of other technological changes—are present in Wales, Deering and throughout much of rural Alaska.

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Bear-Human Interactions at Glacier Bay National Park and Preserve: Conflict Risk Assessment

By Tom Smith, Terry D. DeBruyn, Tania Lewis, Rusty Yerxa, and Steven Partridge

National Park Service photograph

Figure 1.
To the Tlingit and Haida, the grizzly was a Spirit Messenger, a source of power. The grizzly was portrayed in ceremonial dances and symbolically worn on clothing. Tribes honored the bear with names such as Elder Brother and Old Man with the Claws.

Figure 2.
Left: From the safety of deep water, a kayaker observes a brown bear fishing for sockeye salmon *(Oncorhynchus nerka)* on the Alsek River near the Park/Canadian border.

Photograph courtesy of John Hyde © 2003

Many bear-human conflicts have occurred in Alaska parks and refuges, resulting in area closures, property damage, human injury, and loss of life. Human activity in bear country has also had negative and substantial consequences for bears: disruption of their natural activity patterns, displacement from important habitats, injury, and death. It is unfortunate for both people and bears when conflicts occur. Fortunately, however, solutions exist for reducing, and in some instances eliminating, bear-human conflict. This article presents ongoing work at Glacier Bay National Park and Preserve by U.S. Geological Survey (USGS) and National Park Service scientists who are committed to finding solutions for the bear-human conflicts that periodically occurs there.

People and Bears at Glacier Bay: A History of Coexistence and Conflict

Paleontological investigations reveal that both American black *(Ursus americanus)* and brown/grizzly *(U. arctos)* bears have continuously inhabited the Alexander Archipelago for at least the last 35,000 years *(Heaton et al. 1996)*. The oldest evidence of humans in this region dates approximately 10,000 years before present (BP). Native peoples throughout Southeast Alaska, primarily the Tlingit and Haida, integrated the bear into their myth, legend, and art, as well as depended upon them as sources of food, medicine, tools, and clothing. Tlingits preferred brown bear blankets for children's bedding not only for their warmth, but because the hides were believed to protect against illness. Tlingit social and ceremonial life emphasizes the close relationship between humans and bears, and traditional Tlingit bear hunters believed that adherence to certain behaviors was necessary to ensure the success of the hunt *(Figure 1)*.

Native people and bears undoubtedly experienced conflict in Glacier Bay proper, although specific occurrences are now lost to time. The earliest written record of bear-human conflict in what is now the park occurred in August 1912 when frontiersman Allen Hasselborg nearly lost his life to a grizzly along the Bartlett River *(Howe 1996)*. Tasked by C. Hart Merriam, then director of the Smithsonian Museum's mammal collections, to collect bear specimens in the region, Hasselborg met up with a Tlingit hunting party. While talking with them, he boasted that he was not afraid of bears — a bravado deemed reckless and dangerous by the Tlingits. An elderly Tlingit man, Albert Jackson, sharply warned Hasselborg that if he kept boasting, he would anger a bear that would attack him. The next day, several miles up the Bartlett River, Hasselborg saw a large grizzly bear, fired four shots into it, and then pursued the wounded animal. The bear hid on a ledge, ambushed Hasselborg, and nearly killed him. Severely injured, Hasselborg was barely able to make his way back to the hunting party campsite. Upon his arrival, Hasselborg was told by Jackson that he deserved what happened *(Howe 1996)*.

Nearly a century has passed since Hasselborg disregarded the Tlingit hunter's advice. The area has since become a national park, and bears are no longer hunted within its boundaries. People have discovered the unparalleled beauty of Glacier Bay National Park and Preserve, many exploring its pristine shorelines by sea kayak *(Figure 2)*. As backcountry use increases in popularity, so do the reports of skirmishes between bears and people *(Figures 3)*. Conflicts between bears and

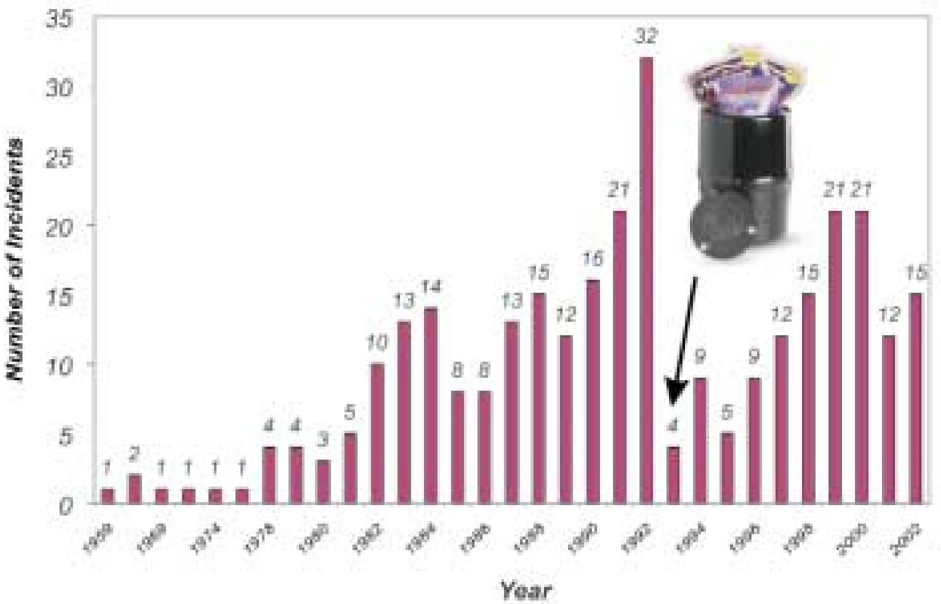

Figure 3. Trends in bear-human incidents at Glacier Bay National Park and Preserve, 1959-2002.

people in North America increased through the twentieth century *(Herrero 2002)*. During that time, bear-human conflicts in Alaska resulted in 52 documented fatalities, hundreds of injuries, and extensive property damage *(Smith unpublished, Middaugh 1987)*.

Notably, a sharp decline in bear-human conflicts occurred at Glacier Bay in the early 1990s as a direct result of a new policy that required campers to store all food in bear-resistant food containers.

This illustrates the impact well-informed management decisions can have in reducing bear-human conflict.

Today, sea kayaking is the predominant recreational activity in Glacier Bay's extensive marine backcountry. Kayakers frequently stay several nights in the backcountry, camping within the narrow ribbon of terrain bordered by ocean and steep-walled mountains. Both brown and black bears inhabit and seasonally occupy these same areas. Beaches not only provide bears with unrestricted movement corridors, but also important foraging opportunities. Seaside habitats are among the earliest to provide bears with new plant growth and access to intertidal areas that host a variety of marine forage items (e.g., mussels, barnacles, and other invertebrate species). Consequently, the potential for bear-human interaction at Glacier Bay's campsites is likely higher than for other areas of the backcountry. It is also more likely that human activity in these areas will displace bears from important forage resources, or interfere with their movement. The majority of bear-human interactions occurring at Glacier Bay are resolved without incident. Nonetheless, there have been two human fatalities, two maulings, and thousands of dollars of property damage. Although no one has been injured in the park since 1980, bear-human conflict is still of great concern to park managers.

Notably, a sharp decline in bear-human conflicts occurred at Glacier Bay in the early 1990s as a direct result of a new policy that required campers to store all food in bear-resistant food containers. This illustrates the impact well-informed management decisions can have in reducing bear-human conflict *(Figure 3)*. Consequently, the National Park Service solicited the aid of bear biologists to find ways to reduce, or even eliminate, bear-human conflict as well as the disturbance of bears by campers. By devising, applying, and evaluating a predictive model for bear-human interactions it may be possible to reduce bear displacement from important habitats, as well as minimize bear-human conflict through education and directives.

The more times people and bears interact, the more likely displacement and bear-human conflicts will occur *(Figure 4)*. We cannot predict when a bear encounter will escalate to a conflict without knowing something about the past behavior of the bear around people, or about how people will behave around bears. We can, however, estimate the potential for bear-human encounters — understanding that the best way to avoid bear-human conflict is to avoid bears, by staying away from places they frequent.

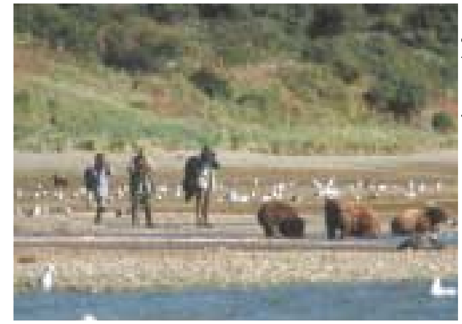

Figure 4. Like the proverbial moth to flame, visitors' fascination with bears occasionally brings the two unreasonably close together. Even when bears receive no food reward, seemingly benign close encounters habituate them to people. Bears unafraid of people, like the ones shown here at Geographic Harbor on the Katmai coast, are more likely to get into trouble.

Devising a Research Approach

We decided to first construct an accurate history of bear activity and conflict at Glacier Bay before attempting to devise research that would provide insight regarding bear-human conflict. Glacier Bay National Park staff have carefully documented instances of bear-human conflict (approximately 300 incidents between 1960-2002), bear sightings (>3700 sightings from 1932-2002), and backcountry campsite use (>8000 records from 1996-2000). Next, we created a computer database into which these records were entered

(Figure 5). This database of 'bear sightings and incidents' presents the distribution of sightings and incidents that have occurred in the bay and enables users to query for specific information through the use of key words. We also used geographic information system (GIS) software to perform spatial analyses of camper and bear use of the bay. This information, in turn, was used to create a temporal-spatial profile of bear and human activity and conflict in the backcountry.

To assess the potential for bear-human interaction at campsites, this research built upon the work of Herrero et al. *(1986)* and MacHutchon and Wellwood *(2002)*. The assumption underlying these previous research efforts was that bears are not randomly distributed across the terrain, but rather that the temporal-spatial pattern of bear whereabouts is largely a function of seasonal forage characteristics.

If this assumption is correct, an assessment of bear habitat quality at campsites should provide a relative index of the amount of seasonal bear activity at those sites. It follows then that if campers avoid areas seasonally important to bears, the number of bear-human encounters will decline. The chance of an encounter escalating to conflict is also affected by campsite characteristics that reduce the ability of bears and people to detect each other early enough to avoid conflicts and by terrain features that reduce options for bears and people to avoid each other. For example,

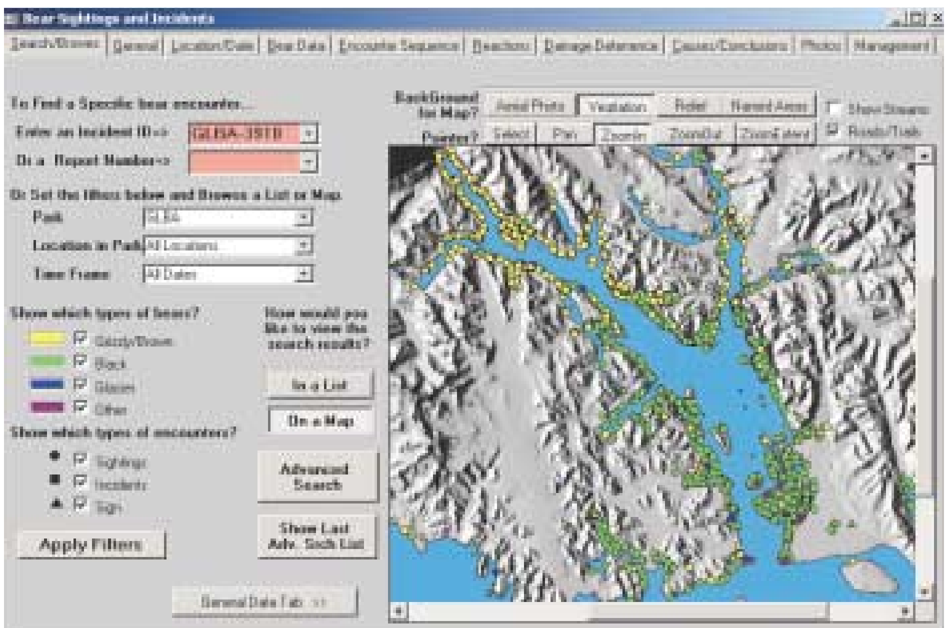

Figure 5. A computerized database contains Glacier Bay's bear sightings and incidents information.

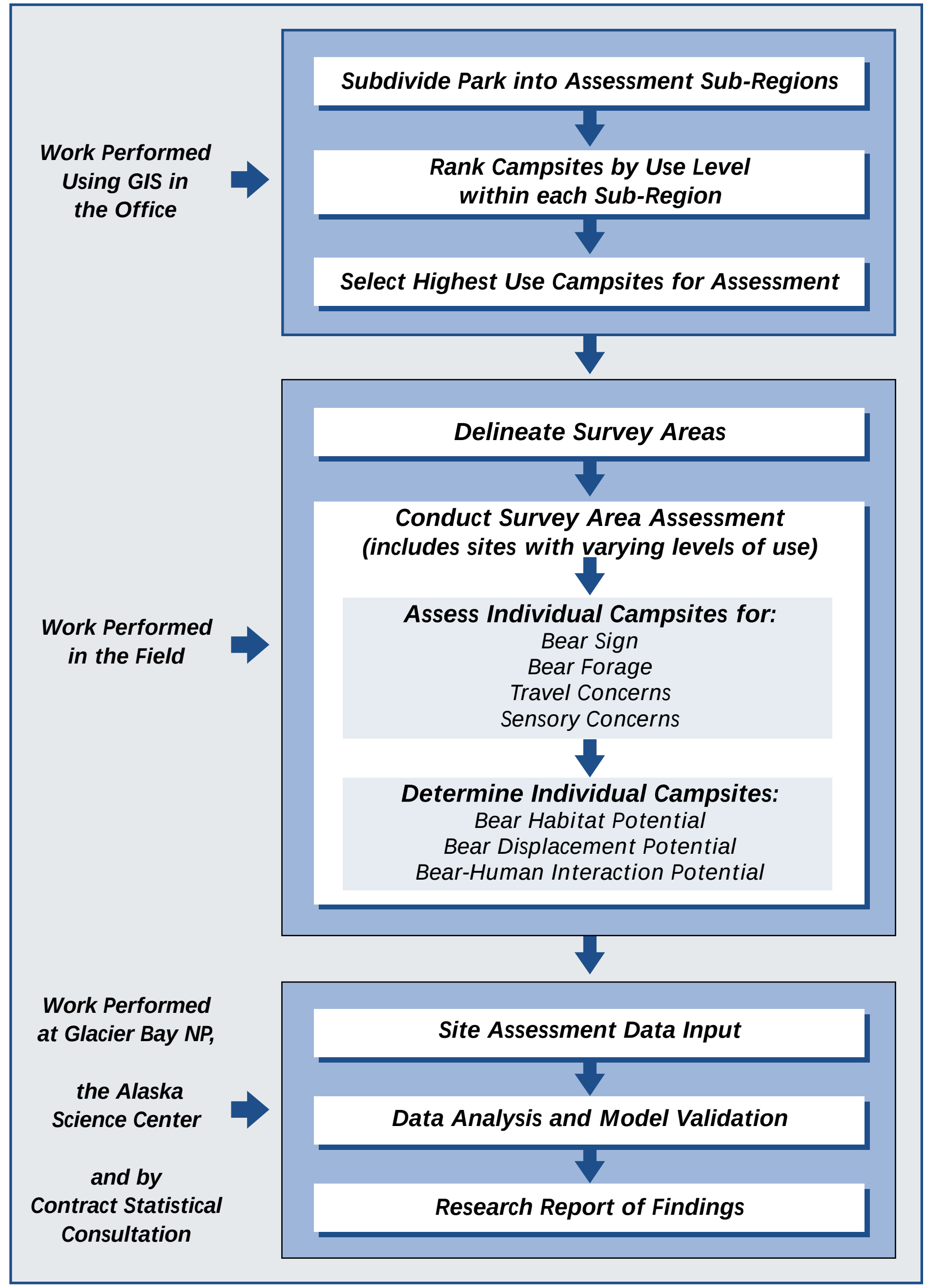

Figure 6. Steps in the campsite risk assessment process, Glacier Bay National Park, Alaska.